

# Special Insert

## Volunteer News - Summer 2007

### Titans of the Forest The Nature of California's Big Trees

by Kathleen M. Wong

Every once in a great while, if you're lucky, you'll come across one during an outdoor ramble: a giant among trees, an oak, Douglas-fir, or redwood so stately and massive that it stops you in your tracks. Its trunk is solid as a Roman column, far too broad to encircle with human arms. Its branches arch overhead like the vault of a cathedral. Its thicket of leaves steeps the ground below in cool black shade.

In the presence of such a colossus, it can be difficult to remember that this tree began life in the same way as all of its lesser woodland companions: a shoot sprouting from a puny acorn, a snowflake-sized redwood seed, or the remains of an ancient mother tree. But the passage of time alone has not been responsible for its greatness. Rather, the interplay of environment, amazing survival strategies, and pure luck is required to transform an ordinary sapling into a sovereign of the forest.

Landmark trees, like top grade real estate, are primarily a function of location, location, location. "The site is probably the dominant factor. Even trees that are not well quipped genetically can grow large if the site permits it," says UC Berkeley forester Richard Harris.

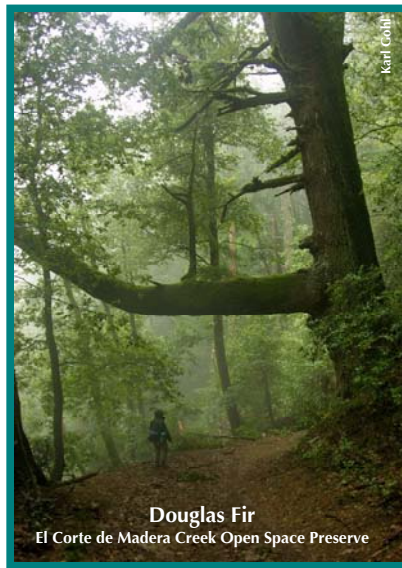
The largest trees on the Peninsula belong to two the tallest tree species in the world: the coast redwood and Douglas fir. The largest individuals tend to be found within Coast Range dells filled with rich alluvial loam.

"In 30 to 40 feet of soil, their roots never run out of places to grow. They can have four times as much root working happily away than in the normal six feet of soil." says UC Berkeley forester Bill Stewart.

Even more critical than lots of loam is an ample and steady supply of water. The fluid demands of a moderately tall 150-foot redwood, for example, aren't trivial: such a tree loses more than 1,300 pounds of water per day.

Understanding how one tree can go through so much moisture requires a bit of background in plant physiology. Within each living tree stands a column of water that extends from its deepest roots to its tallest shoots. The tree uses this water to circulate nutrients, expand its tissues, and regulate normal cell processes.

Two formidable forces tug at this column from opposite directions: gravity below, and the sun above. When a tree photosynthesizes, it opens its leaf pores, or stomata, to take in carbon dioxide. But opening these pores also allows water to evaporate. On hot days, accelerated evaporation can stretch the water column in a mature redwood or Douglas fir to the breaking point.



"It would be a major catastrophe for that column of water to snap," says plant ecophysiologicalist George Koch of Northern Arizona University. "The tree will keep losing water at the top, but those tissues won't get resupplied. Then you get branches or the whole top dying back." Trees do close their stomata on scorching summer days to avert such a disaster. But there's a tradeoff: conserving water also shuts down photosynthesis, which in turn limits growth.

"If you assumed that every redwood in California has the same potential to grow tall, those growing in locations where the soil is drier are not going to get as tall because these limits will be experienced more frequently," Koch adds.

To satisfy their prodigious thirst, redwoods employ a rather startling strategy: they literally drink fog. Plant ecophysiologicalist Todd Dawson of UC Berkeley has found that during California's rainless summers, almost 20 percent of the water within Santa Cruz Mountains redwoods originates from the area's signature marine mists.

When fog billows into a redwood forest, it condenses into fat droplets on leaves, then falls into the soil, where it can be absorbed by roots. Even more intriguing, Dawson has found that redwoods are almost certainly able to sip fog directly from their leaves. How this occurs remains unclear. Redwood needles are coated with a waxy, water repellent cuticle, as are most plants. Nor can water easily enter the stomata, as these openings are too small for water droplets to squeeze through. Whatever the case, water from fog offers redwoods just the hydration advantage they need to persist in central California.

"I am more and more convinced that fog is why we still find these enormous trees living in an otherwise dry Mediterranean climate. It's an important source of moisture during the summer months, when no other sources are available," Dawson says.

*'Titans of the Forest' continued...*

Big trees may also use the water stored in their immense trunks to get them through drier times. Plant ecophysicologist Nathan Phillips of Boston University and colleagues found that the reservoir of water in the xylem of 80-foot tall Douglas-firs accounted for up to 23 percent of their total daily water use.

The very largest trees rival the size of skyscrapers. Just last year, researchers found the largest living tree on record: a coast redwood in Humboldt County that was 378.1 feet tall. So if trees had an unlimited supply of water, could redwoods or Douglas firs reach fifty, sixty, or more stories high? They're certainly built for it; structural analyses suggest that redwoods are so over-engineered that it is almost impossible for them to collapse. Instead, the major factor limiting redwood height may be something as subtle as low water pressure within the highest leaves.

Water expands plant tissues like a balloon, keeping leaves plump and unfurled. Koch and colleagues have found that this internal turgor pressure declines with tree height. This means that the tops of tall redwoods subsist in constant drought. The result: leaves that appear flat and feathery near the base of the tree shrink to tiny, juniper-like scales more than 150 feet up.

"Some guidebooks describe redwoods with two kinds of leaves, the feathery ones growing in the shade and the scaly ones in the sun," Koch says. "In fact, tall trees show a gradient of that characteristic from bottom to top."

Over a life that can span more than two thousand years, redwoods make the most of the resources they do have. "Redwoods grow faster than any temperate climate tree in North America by a long shot," Stewart says. "They're one of the most efficient trees on the planet."

Like redwoods, oaks attain their great size by outlasting the competition. Manzanita and other pioneer species may shoot up quickly around them, but die away just as oak saplings are gaining steam.

A preference for drier soil also forces oaks to grow at a stately pace. "Oaks virtually stop growing nine months of the year. Their stomata just shut down around 10 a.m.; they can't grow when it's too hot." Stewart says.

In summer, the arid soils of oak woodlands can harden to the consistency of cured cement. During these times, surface moisture is almost impossible to come by. To meet their water needs, Dawson has found, large oaks actively redistribute water within the soil column. At night, when their stomata are closed, oaks continue to absorb water through their extraordinarily deep root systems. This moisture first circulates into surface rootlets, then wicks into the drier dirt. During the day, that water is taken up again by the tree again. "The plant is acting like a conduit for water deep in the soil," Dawson says.

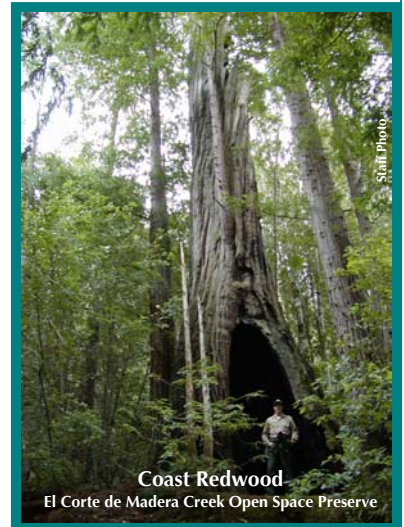
The biggest and oldest California oaks have been shaped by fire as much as by water. The Ohlone people of central coastal California, who have resided in the area for more than 12,000

years, burned the grasses beneath the Peninsula's oak forests on a regular basis. "Indian practices favored the largest oaks (from 80 to 500 years old) which also produced the largest number of acorns, and increased their longevity," writes ecologist M. Kat Anderson in her book *Tending the Wild*. Periodic burning reduced the chance of tree-killing conflagrations by consuming fuels that could ignite crown fires. The flames also released minerals in the soil, stimulating acorn production, while eliminating fungus infections, insects, and other pests.

As monarchs of their ecosystems, big trees are a magnet for many woodland creatures. The prodigious acorn crops beneath large oaks draw deer and squirrels, mice and scrub jays seeking to fatten up before winter. And many large, aged oaks are essentially a hodgepodge of dead and living branches. Acorn, Lewis's, and northern flicker woodpeckers use limbs already decaying from fungi and insects to drill cozy nesting cavities. Long after they depart, pygmy and saw-whet owls, raccoons, and western bluebirds will use these weatherproof nooks to raise their own young.

Redwoods are almost an entire universe unto themselves. Researchers in Humboldt County have documented unique assemblages of lichens, a new species of earthworm, and plants ranging from rhododendrons to bay laurels sprouting in the detritus that has accumulated atop high redwood branches. And the marbled murrelet, an endangered native seabird, nests almost exclusively in mature old-growth trees such as redwoods with branches broad enough to support its nest of mosses and lichens. Lower down, redwoods with trunks hollowed out by fire provides habitat for more familiar animals. "I've seen feral pigs sleeping there in the rain, and bats hanging in the upper cracks," says Stan Hooper, a naturalist and maintenance supervisor with the Midpeninsula Regional Open Space District.

Then, of course, there's the impact of truly big, old trees on two-legged visitors to the forest. "If you're standing next to a 1,500-year-old tree, it's a bit like looking through a window into the past," says Stan Hooper (pictured right). "They are largely unchanged in a world that is shifting at such a rapid rate." Indeed, it may be not be great size that makes big trees so inspiring to us humans, but their role as living ambassadors of a previous age.



*Kathleen M. Wong is a freelance writer specializing in science and the environment. Based in Oakland, she hikes among big trees every chance she gets.*